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(54) **Hydraulic oil composition for shock absorbers**

(57) The present invention provides a hydraulic oil composition comprising a base oil composed of a mineral oil (A) and/or synthetic oil (B) incorporated with 20 wt% or less, based on the whole composition, of one or more types of additives (C) including viscosity index improver and/or pour point depressant, and having a kinematic viscosity of 1 to 20 mm²/s at 100°C, a viscosity index of 140 or more and a Brookfield viscosity of 2000 mPa·s or less at -40°C, wherein the mineral oil (A) is a deeply dewaxed mineral oil (a) having a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less, or a mixed mineral oil of the deeply dewaxed mineral oil (a) and a low-viscosity mineral oil (b) having a kinematic viscosity of 1.0 to 6.0 mm²/s at 40°C, and the synthetic oil (B) is a poly-α-olefin (c) having a kinematic viscosity of 1.5 to 45 mm²/s at 100°C, and/or an ester compound (d) having a kinematic viscosity of 1.5 to 20 mm²/s at 100°C and pour point of -30°C or less.

EP 0 992 570 A2

Description

BACKGROUND OF THE INVENTION

5   FIELD OF THE INVENTION

[0001]   This invention relates to a hydraulic oil composition for shock absorbers, more particularly a hydraulic oil composition for shock absorbers, excellent in damping force stability and capable of securing riding quality, in particular at low temperature.

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DESCRIPTION OF THE RELATED ART

[0002]   A hydraulic shock absorber is normally used for an automobile body suspension, in order to control vibration, and improve riding quality and steering stability. The shock absorber is basically of a cylindrical structure, where the hydraulic piston is normally provided with small holes. The shock absorber of this structure allows the hydraulic oil to pass through the holes as the piston moves up and down, resistance to the oil increasing in proportion to the piston speed. A guide bush is provided at the sliding portion between the cylinder and piston rod, to prevent their wear. It also works as a guide. These members are sealed as a whole to prevent oil leakage. Other shock absorber structures include double tube and gas-sealed types.

[0003]   In the shock absorber of such a structure, a number of complex types of friction are generated, e.g., between the piston rod and guide bush, piston rod and seal, and piston and cylinder, as mentioned earlier. Moreover, it is necessary to relax vibration to an automobile running under severe conditions, and thereby to secure riding quality and steering stability. Therefore, a hydraulic oil for shock absorbers is required to have various functions, e.g., high resistance to wear, durability and friction characteristics.

[0004]   Similar shock absorbers are used in other areas in an automobile, e.g., engine support, shock absorber for the bumper and door checker. The hydraulic shock absorber is also used for aircraft, to absorb shocks generated during the takeoff and landing. The hydraulic oil for these absorbers are required to have similar functions described above.

[0005]   Various techniques have been proposed to develop hydraulic oil of high resistance to wear, durability and friction characteristics for shock absorbers. These compositions comprise a lubricant base oil incorporated with zinc dithiophosphate (Zn-DTP) together with an oiliness agent (e.g., long-chain fatty acid) and detergent/dispersant (Japanese Laid-open Patent Application No. 55-165996), with a boron-containing detergent/dispersant and phosphate ester (Japanese Patent Publication No. 2-44879), with a phosphate ester or the like and alkanol amine (Japanese Laid-open Patent Application No. 5-255683), with a phosphate ester or the like and aliphatic polyamine (Japanese Laid-open Patent Application No. 7-224293), and with a phosphate ester or the like and aliphatic polyamine or monoamine (Japanese Laid-open Patent Application No. 7-258673).

[0006]   A shock absorber is a device to control vibration. Vibration-controlling force, normally referred to as damping force, determines, together with working speed, absorber performance. It is essential for a shock absorber, in particular that for automobiles, to stably sustain damping force, because it works to relax vibration to an automobile running under severe conditions and thereby to secure its riding quality and steering stability. Damping force consists of two or more resistance components, involving, e.g., resistance to flow of liquid, i.e., hydraulic oil, and frictional force in each member of a shock absorber. It is therefore necessary for the hydraulic oil to have as stable viscosity and frictional characteristics as possible, in order to keep damping force within a specific range.

[0007]   However, the hydraulic oils for shock absorbers proposed so far are mostly for improving resistance to wear and friction characteristics, as described above, and few have attempted to improve viscosity characteristics. One of few compositions developed to improve viscosity characteristics is a lubricant composition for machines with an orifice mechanism, comprising a deeply dewaxed mineral base oil having a kinematic viscosity of 3 to 500 cSt at 40°C, pour point of -25°C or less and cloud point of -25°C or less, incorporated with a viscosity index improver and phosphorus-based extreme pressure agent (Japanese Laid-open Patent Application No. 63-280797).

[0008]   A shock absorber works over a fairly wide temperature range, and hence should change in viscosity as moderately as possible with temperature, in order to prevent change in damping force. In particular, viscosity of a hydraulic oil for shock absorbers increases as temperature decreases, and excessively increased viscosity at low temperature will cause excessively high damping force, preventing the absorber from working smoothly, and deteriorating riding quality and steering stability of the automobile. The hydraulic oil for shock absorbers, therefore, has been increasingly demanded to show sustained damping force at low temperature, or greatly reduced damping force at a low temperature level up to -20°C to -40°C, with the result that it is strongly required to show good viscosity characteristics at low temperature.

[0009]   However, the conventional hydraulic oil for shock absorbers, comprising a low-viscosity base oil incorporated

with one or more types of additives, e.g., viscosity index improver and pour point depressant, has disadvantages; e. g.; increased volatility as base oil viscosity is decreased to improve viscosity at low temperature, causing increased evaporation and changed damping force as a result of cavitation. A hydraulic oil incorporated with large quantities of viscosity index improver and pour point depressant tends to decrease in viscosity when exposed to a shear stress, generated when the piston is sliding or the oil flows through an orifice. Greatly reduced viscosity will cause decreased damping force.

[0010] For the above reasons, a hydraulic oil for shock absorbers is strongly required to show good low-temperature viscosity characteristics, volatility, shear stability, and damping force stability from high to low temperature.

[0011] It is an object of the present invention to provide a hydraulic oil composition for shock absorbers which shows excellent low-temperature viscosity characteristics, volatility, shear stability, and damping force stability from high to low temperature, to meet the above requirements.

DESCRIPTION OF THE INVENTION

[0012] The present invention is directed to a hydraulic oil composition for shock absorbers exhibiting sufficient characteristics required for shock absorbers, i.e., good low-temperature viscosity characteristics, volatility, shear stability, and damping force stability from high to low temperature, when it has a kinematic viscosity at 100°C, viscosity index and Brookfield viscosity at -40°C each in a specific range, and its base oil is composed of a deeply dewaxed mineral oil and/or synthetic oil having specific properties and is incorporated with specific quantities of a viscosity index improver (e.g., polymethacrylate-based, olefin copolymer-based and star-shaped polymer) and/or pour point depressant (e.g., acrylate-based and polymethacrylate-based polymer).

[0013] The present invention provides a hydraulic oil composition comprising a base oil composed of a mineral oil (A) and/or synthetic oil (B) incorporated with 20 wt% or less, based on the whole composition, of a viscosity index improver and/or pour point depressant, and having the following viscosity characteristics; kinematic viscosity of 1 to 20 mm²/s at 100°C, viscosity index of 140 or more and Brookfield viscosity of 2000 mPa•s or less at -40°C:

the mineral oil (A) is a deeply dewaxed mineral oil (a) having a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less, or a mixed mineral oil of the deeply dewaxed mineral oil (a) and a low-viscosity mineral oil (b) having a kinematic viscosity of 1.0 to 6.0 mm²/s at 40°C (content of the low-viscosity mineral oil (b) is below 20 wt%, based on the whole mixed mineral oil), and

the synthetic oil (B) is a poly-α-olefin (c) having a kinematic viscosity of 1.5 to 45 mm²/s at 100°C, and/or an ester compound (d) having a kinematic viscosity of 1.5 to 20 mm²/s at 100°C and pour point of -30°C or less.

[0014] The hydraulic oil composition of the present invention for shock absorbers shows, as described above, good low-temperature viscosity characteristics, volatility, shear stability, and damping force stability from high to low temperature, and the preferred embodiments include the following compositions.

(1) A hydraulic oil composition for shock absorbers, comprising a base oil composed of a deeply dewaxed mineral oil (a) which has a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less.

(2) A hydraulic oil composition for shock absorbers, comprising a base oil composed of a mixed mineral oil of the above deeply dewaxed mineral oil (a) and a low-viscosity mineral oil (b), the former having a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less and the latter having a kinematic viscosity of 1.0 to 6.0 mm²/s at 40°C (content of the low-viscosity mineral oil (b) is below 20 wt%, based on the whole mixed mineral oil).

(3) A hydraulic oil composition for shock absorbers, comprising a base oil composed of a mixed mineral oil of the above deeply dewaxed mineral oil (a) and a low-viscosity mineral oil (b¹), the former having a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less and the latter having a kinematic viscosity of 1.0 to 2.5 mm²/s at 40°C (content of the low-viscosity mineral oil (b¹) is below 20 wt%, based on the whole mixed mineral oil).

(4) A hydraulic oil composition for shock absorbers, comprising a base oil composed of a mixed mineral oil of the above deeply dewaxed mineral oil (a) and a low-viscosity mineral oil (b²), the former having a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less and the latter having a kinematic viscosity of 2.5 to 6.0 mm²/s at 40°C (content of the low-viscosity mineral oil (b²) is below 20 wt%, based

on the whole mixed mineral oil).

(5) The hydraulic oil composition for shock absorbers of one of the above (1) to (4), wherein said deeply dewaxed mineral oil has a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -35°C or less and cloud point of -30°C or less.

(6) A hydraulic oil composition for shock absorbers, comprising a synthetic base oil composed of a poly-α-olefin (c) having a kinematic viscosity of 1.5 to 45 mm²/s at 100°C and/or an ester compound (d) having a kinematic viscosity of 1.5 to 20 mm²/s at 100°C and pour point of -30°C or less.

(7) The hydraulic oil composition for shock absorbers of the above (6), wherein said base oil is composed of 70 to 90 wt% of poly-α-olefin (c) and 10 to 30 wt% of the ester compound (d).

(8) A hydraulic oil composition for shock absorbers, comprising a partially synthetic base oil composed of the deeply dewaxed mineral oil (a) having a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less, the poly-α-olefin (c) having a kinematic viscosity of 1.5 to 45 mm²/s at 100°C and/or the ester compound (d) having a kinematic viscosity of 1.5 to 20 mm²/s at 100°C and pour point of -30°C or less.

(9) A hydraulic oil composition for shock absorbers, comprising a partially synthetic base oil composed of a mixed mineral oil of the above deeply dewaxed mineral oil (a) and the low-viscosity mineral oil (b), the former having a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less and the latter having a kinematic viscosity of 1.0 to 6.0 mm²/s at 40°C (content of the low-viscosity mineral oil (b) is below 20 wt%, based on the whole mixed mineral oil), and the poly-α-olefin (c) having a kinematic viscosity of 1.5 to 45 mm²/s at 100°C and/or the ester compound (d) having a kinematic viscosity of 1.5 to 20 mm²/s at 100°C and pour point of -30°C or less.

(10) A hydraulic oil composition for shock absorbers, comprising a base oil incorporated with 20 wt% or less of a common viscosity index improver for lubricant oil (e.g., polymethacrylate-based, olefin copolymer-based and star-shaped polymer) and/or pour point depressant (e) (e.g., acrylate-based and polymethacrylate-based polymer).

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0015]   The present invention is described in detail, below.

(1) Lubricant base oil

[0016]   The deeply dewaxed mineral oil (a) for the hydraulic oil composition of the present invention for shock absorbers may be obtained by refining a distillate of a paraffinic or intermediate base crude, using a common method and further dewaxing it deeply.

[0017]   The distillate means that obtained by atmospheric distillation of a crude or by vacuum distillation of atmospheric residua. The refining process is not limited, and may fall into one of the five processes (1) to (5) below:

(1) Hydrotreatment of a distillate, which may be optionally followed by distillation in the presence of an alkali or washing with sulfuric acid.

(2) Solvent refining of a distillate, which may be optionally followed by distillation in the presence of an alkali or washing with sulfuric acid.

(3) Hydrotreatment of a distillate in 2 stages.

(4) Hydrotreatment of a distillate in 3 stages.

(5) Hydrotreatment of a distillate in 2 stages, followed by distillation in the presence of an alkali or washing with sulfuric acid.

[0018]   One example of the refining process comprising a plurality of steps is described below:

[0019]   A lubricant stock of a paraffinic or intermediate base crude, produced by a common method, is hydrotreated

under severe conditions, to remove aromatics or others unsuited for a lubricant fraction or convert them into active components. Sulfur and nitrogen are removed almost completely by the above step.

[0020] The effluent is distilled under a vacuum for adjusting its viscosity, and then treated by a known solvent de-waxing method to have a pour point of the normal paraffinic base oil, i.e., -15°C to -10°C.

[0021] The dewaxed oil is further hydrotreated, as required, to saturate most of the remaining aromatics with hydrogen, to improve thermal and chemical stability of the lubricant base oil. It may be still unsuited for a lubricant oil, because of its high pour point, and is further treated by deep dewaxing. This step is effected by solvent dewaxing under more severe conditions or catalytic hydrodewaxing, in which paraffins (mostly normal paraffins) adsorbed on pores of a zeolite catalyst are selectively cracked in a hydrogen atmosphere, to remove the waxy component.

[0022] The hydrotreatment conditions, although varying depending on feed properties and the like, are generally in the following ranges; reaction temperature: 200 to 480°C, preferably 250 to 480°C, hydrogen pressure: 5 to 300 kg/cm^2, preferably 30 to 250 kg/cm^2, and hydrogen gas rate: 30 to 3000 Nm^3 per kL of distillate feed, preferably 100 to 2000 Nm^3/kL. The catalyst used for hydrodewaxing comprises a carrier of, e.g., alumina, silica, silica-alumina, zeolite, activated carbon or bauxite, which is impregnated with one or more catalytically active group VI and/or VIII metals, preferably cobalt, nickel, molybdenum, tungsten and the like. The catalyst is preferably pre-sulfided.

[0023] As described above, the distillate is subject to various types of treatment, after being hydrotreated. When it is to be hydrotreated in 2 or 3 stages, the conditions may be set within the above ranges. The conditions for the first, second and third stages may be the same or different. However, these conditions normally become severer in the descending order of the stages, those for the last stage being the most severe.

[0024] Distillation in the presence of an alkali is adopted as a step to remove traces of acidic impurities and thereby to improve stability of the distillate. It is effected in the presence of an alkali, e.g., NaOH or KOH, under a vacuum.

[0025] Washing with sulfuric acid is normally adopted as a finishing step for the petroleum product. It is to improve properties of the distillate by removing aromatic hydrocarbons (in particular, polynuclear aromatic hydrocarbons), olefins and sulfur compounds.

[0026] The distillate is treated by one of the above five processes (1) to (5) combining a plurality of steps, preferably by one of (1), (3) and (4).

[0027] The deeply dewaxed mineral base oil (a) for the present invention, prepared by the above method, should have a kinematic viscosity of 2 to 3 mm^2/s at 100°C, preferably 2 to 2.5 mm^2/s, pour point of -30°C or less, preferably -35°C or less, and cloud point of -27.5°C or less, preferably -30°C or less.
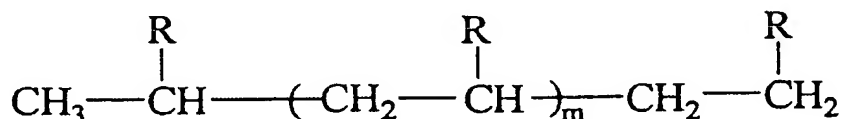
[0028] Kinematic viscosity below 2 mm^2/s at 100°C is undesirable, because of possibly deteriorated characteristics related to wear resistance and evaporation. Kinematic viscosity above 3 mm^2/s is also undesirable, because of possibly deteriorated viscosity characteristics, i.e., fluidity, at low temperature. Pour point above -30°C or cloud point above -27.5°C is undesirable, because of possibly deteriorated fluidity at low temperature.

[0029] For the hydraulic oil composition of the present invention for shock absorbers, the deeply dewaxed mineral oil (a) as the base oil may be mixed with the low-viscosity mineral oil (b) having a kinematic viscosity of 1.0 to 6.0 mm^2/s at 40°C. Some of the examples of the low-viscosity mineral oil include: that having a kinematic viscosity of 1.0 to 2.5 mm^2/s at 40°C (b^1), preferably 1.0 to 2.1 mm^2/s, and that having a kinematic viscosity of 2.5 to 6.0 mm^2/s at 40°C (b^2), preferably 2.6 to 3.5 mm^2/s. When mixed with the low-viscosity mineral oil (b), the deeply dewaxed mineral oil (a) can give much more improved fluidity at low temperature than it would give by itself.

[0030] Kinematic viscosity below 1 mm^2/s at 40°C is undesirable, because of possibly deteriorated characteristics related to wear resistance and evaporation. Kinematic viscosity above 6 mm^2/s is also undesirable, because of possibly deteriorated viscosity characteristics, i.e., fluidity, at low temperature.

[0031] When the deeply dewaxed mineral oil (a) is mixed with the low-viscosity mineral oil (b) to prepare the base oil for the hydraulic oil composition of the present invention for shock absorbers, content of the mineral oil (b) should be below 20 wt%, based on the whole mixed mineral oil, preferably 10 wt% or less. Content of the mineral oil (b) beyond the above range is undesirable, because of possibly deteriorated evaporation characteristics, and insufficient lubricating and friction characteristics inherent to the hydraulic oil for shock absorbers.

[0032] The poly-α-olefin (c) which can be used as the base oil for the hydraulic oil composition of the present invention for shock absorbers is a synthetic lubricant oil, also referred to as an α-olefin oligomer, and represented by the following general formula:

$$CH_3-\underset{\underset{R}{|}}{CH}-(CH_2-\underset{\underset{R}{|}}{CH})_{\overline{m}}-CH_2-\underset{\underset{R}{|}}{CH_2}$$

(wherein, R is an alkyl group having a carbon number of 4 to 12; and (m) is 0 to 30). The poly-α-olefin (c) should have a kinematic viscosity of 1.5 to 45 mm²/s at 100°C, preferably 1.7 to 40 mm²/s. Kinematic viscosity below 1.5 mm²/s is undesirable because of excessive vaporization of the oil, and above 45 mm²/s is also undesirable because of possibly deteriorated viscosity characteristics at low temperature. More concretely, the poly-α-olefin compounds useful for the present invention include dimer to decamer of 1-octene, 1-decene and 1-dodecene, preferably the ones of low degree of polymerization, e.g., dimer to tetramer of 1-decene, viewed from viscosity index and pour point.

[0033] The ester compound (d) which can be used as the base oil for the hydraulic oil composition of the present invention for shock absorbers is not limited, so long as it has a kinematic viscosity of 1.5 to 20 mm²/s at 100°C, preferably 1.5 to 10 mm²/s, and pour point of -30°C or less, preferably -35°C or less. These ester compounds include a dibasic acid ester (diester) and polyol ester (hindered ester), and a dibasic acid ester (diester) is particularly preferable for its, e.g., high viscosity index and fluidity at low temperature.

[0034] A dibasic acid ester is generally produced by esterification of 1 part of dibasic acid with 2 parts of alcohol. The dibasic acids as the stock compounds for the dibasic acid esters useful for the present invention include adipic acid, azelaic acid, sebacic acid and dodecanoic diacid. The alcohols widely used include primary alcohols with a side chain having a carbon number of 7 to 13, e.g., 2-ethyl hexanol (C_8), isodecanol (C_{12}) and tridecanol (C_{13}). The dibasic acid esters useful for the present invention include di-2-ethylhexylsebacate (DOS), di-2-ethylhexyladipate (DOA), di-isodecyladipate (DIDA), diisooctyladipate (DIOA), and di-2-ethylhexylazelate (DOZ).

[0035] A polyol ester is normally an ester of neopentyl polyol and monobasic fatty acid. The neopentyl polyols as the stock compounds for the polyol esters useful for the present invention include divalent alcohols, e.g., neopentyl glycol (NPG); trivalent alcohols, e.g., trimethylolpropane (TMP) and trimethylolethane (TME); tetravalent alcohols, e. g., pentaerythritol (PE); and hexavalent alcohols, e.g., dipentaerythritol (DPE), of which trimethylolpropane (TMP) and pentaerythritol (PE) are more widely used. The monobasic fatty acids widely used include straight-chain or branched acids having a carbon number of 3 to 13. A mixture of two or more straight-chain fatty acids, which may be incorporated with a small quantity of branched acid, is widely used to improve pour point.

[0036] The poly-α-olefin compound (c) and ester compound (d) can be used as the base oil for the hydraulic oil composition of the present invention for shock absorbers, either individually or in combination, the latter being more preferable. The ratio of the poly-α-olefin compound (c) to ester compound (d), i.e., c/d ratio, is normally 50:50 to 95:5 by weight, preferably 70:30 to 90:10, more preferably 75:25 to 85:15. The c/d ratio in the above range makes the hydraulic oil composition of the present invention highly compatible with sealant rubber, high in viscosity index and excellent in viscosity characteristics at low temperature.

[0037] The mineral oil (A) and synthetic oil (B) can be used either individually or in combination as the base oil for the hydraulic oil composition of the present invention for shock absorbers.

(2) Viscosity index improver and/or pour point depressant (e)

[0038] A viscosity index improver and pour point depressant (e) may be incorporated either individually or in combination in the hydraulic oil composition of the present invention for shock absorbers. A common viscosity index improver for lubricant oil can be used for the present invention. These include polymethacrylate-based, olefin copolymer-based and star-shaped polymer. The pour point depressants useful for the present invention include acrylate-based and polymethacrylate-based polymer. The viscosity index improver for the present invention is preferably polymethacrylate-based. A polymethacrylate-based viscosity index improver is subdivided into dispersion and non-dispersion type, and either can be used. It preferably has a weight-average molecular weight of 10,000 to 300,000, more preferably 10,000 to 120,000. The one having a weight-average molecular weight below 10,000 will show limited effect of reducing viscosity at low temperature, although good in shear stability, and the one having a molecular weight above 300,000 has insufficient shear stability, although good in the effect of reducing viscosity at low temperature.

[0039] Content of the viscosity index improver and/or pour point depressant (e) is 20 wt% or less, based on the whole composition, preferably 4 to 10 wt%. Increasing the content beyond 20 wt% will deteriorate shear stability of the composition and increase its viscosity excessively at low temperature.

(3) Other additives

[0040] The a hydraulic oil composition of the present invention for shock absorbers may be incorporated with one or more types of other additives, as required, so long as the object of the present invention is not damaged. The additives which may be useful for the present invention include friction modifier, antiwear agent, antioxidant, ashless dispersant, metallic detergent, corrosion inhibitor, rust inhibitor, and antifoamant.

[0041] The friction modifiers useful for the present invention include fatty acids (e.g., oleic acid and stearic acid), higher alcohols (e.g., oleyl alcohol), fatty acid esters, phosphate esters, phosphite esters, phosphate ester amine salts, fats, polyalcohol esters, sorbitan esters and aliphatic amines. If present at all, it is incorporated normally at 0.05 to 3.0

wt%.

[0042] The antiwear agents useful for the present invention include metallic (e.g., Zn, Pb, Sb and Mo) salts of dithiophosphoric acid, metallic (e.g., Zn and Mo) salts of dithiocarbamic acid, metallic (e.g., Pb) salts of naphthenic acid, metallic (e.g., Pb) salts of fatty acid, phosphate esters, phosphite esters, phosphate ester amine salts, sulfided fats, sulfur compounds and boron compounds. If present at all, it is incorporated normally at 0.05 to 3.0 wt%.

[0043] The antioxidants useful for the present invention include amine-based ones, e.g., alkylated diphenyl amine, phenyl-α-naphthyl amine and alkylated phenyl-α-naphthyl amine; phenol-based ones, e.g., 2,6-di-t-butyl phenol and 4,4'-methylene bis-(2,6-di-t-butyl phenol); phosphorus-based ones, e.g., phosphite; and sulfur-based ones, e.g., dilauryl-3,3'-thiodipropionate. If present at all, it is incorporated normally at 0.05 to 2.0 wt%.

[0044] The ashless dispersants useful for the present invention include those based on succinimide, succinamide, benzyl amine and succinic acid ester. A boron-containing one can be also used. If present at all, it is incorporated normally at 0.05 to 7.0 wt%.

[0045] The metallic detergents useful for the present invention include Ca sulfonate, Mg sulfonate, Ba sulfonate, Ca phenate, Mg phenate, Ba phenate, Ca salicylate, Mg salicylate and Ba salicylate. If present at all, it is incorporated normally at 0.1 to 5.0 wt%.

[0046] The corrosion inhibitors useful for the present invention include benzotriazole, and derivatives of benzotriazole and thiadiazole. If present at all, it is incorporated normally at 0.01 to 2.0 wt%.

[0047] The rust inhibitors useful for the present invention include carboxylic acid, carboxylates, sulfonates, amines, and alkenyl succinates and their half esters. It may be incorporated, as required.

[0048] The antifoamants useful for the present invention include dimethyl polysiloxane and polyacrylate. It may be incorporated, as required.

(4) Hydraulic oil composition for shock absorbers

[0049] The hydraulic oil composition of the present invention for shock absorbers should have the following viscosity characteristics to secure excellent damping force stability and, in particular riding quality at low temperature; kinematic viscosity of 1 to 20 mm²/s at 100°C, preferably 2 to 8 mm²/s, viscosity index of 140 or more, preferably 145 or more, and Brookfield (BF) viscosity of 2000 mPa·s or less at -40°C, preferably 1700 mPa·s or less.

[0050] Excessive evaporation and deteriorated wear resistance of the composition may result when its kinematic viscosity is below 1 mm²/s at 100°C, whereas viscosity of the composition may be excessively high at low temperature when its kinematic viscosity is above 20 mm²/s. Viscosity of the composition may be excessively high at low temperature when its viscosity index is below 140. Damping force of the composition may be excessively high at low temperature when its Brookfield viscosity is above 2000 mPa·s at -40°C.

EXAMPLES AND COMPARATIVE EXAMPLES

[0051] The present invention is described below more concretely by Examples and Comparative Examples, which by no means limit the present invention. Brookfield viscosity, volatility and shear stability were measured for Examples and Comparative Examples by the following methods:

(1) Brookfield Viscosity

[0052] Brookfield (BF) viscosity at -40°C was measured by a Brookfield viscosimeter, in accordance with ASTM D2983.

(2) Volatility

[0053] Volatility was evaluated from NOACK evaporated quantity for the sample kept at 120°C for 3 h, in accordance with DIN51581.

(3) Shear Stability

[0054] The sample was irradiated with sound waves to shear it, to evaluate its shear stability from viscosity reduction rate before and after the irradiation at 100°C, in accordance with ASTM D2603. The test conditions were: sample quantity 30 mL; sound wave output 10 kHz; irradiation time 30 minutes; and circulated water temperature 38°C.

EXAMPLE 1

[0055]   The lubricant base oil used was the deeply dewaxed mineral oil, which had a kinematic viscosity of 2.4 mm^2/s at 100°C, pour point of -35°C and cloud point of -30°C or less. It was incorporated with a polymethacrylate-based viscosity index improver (weight-average molecular weight: 75,000) at 4.0 wt% based on the whole composition and given necessary quantities of other additives, e.g., antioxidant and antiwear agents, to prepare a hydraulic oil composition for shock absorbers. The composition thus prepared was measured for its viscosity characteristics, volatility and shear stability, and evaluated by these characteristics. The results are given in Table 1. The hydraulic oil composition for shock absorbers show good viscosity characteristics (kinematic viscosity of 3.1 mm^2/s at 100°C, viscosity index of 149 and Brookfield viscosity of 1650 mPa·s at -40°C), NOACK evaporated quantity of 4.3 wt% as a measure of volatility, and viscosity reduction rate of 4.0% as a measure of shear stability, determined by the sound wave method.

TABLE 1

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6
Deeply dewaxed mineral oil (a), wt% * Kinematic viscosity: 2.4 mm²/s at 100°C	100	96	94	95	85	--
Low-viscosity mineral oil (b), wt% * (b¹) Kinematic viscosity: 1.8 mm²/s at 40°C	--	4	6	--	--	--
(b²) Kinematic viscosity: 3.1 mm²/s at 40°C	--	--	--	5	15	--
Normal solvent dewaxed mineral oil (a), wt% * Kinematic viscosity: 2.7 mm²/s at 100°C	--	--	--	--	--	--
Poly-α-olefin (c), wt% * (c¹) Kinematic viscosity: 1.7 mm²/s at 100°C	--	--	--	--	--	80
Ester compound (d), wt% * (d¹) Kinematic viscosity: 2.4 mm²/s at 100°C	--	--	--	--	--	20
(d²) Kinematic viscosity: 4.3 mm²/s at 100°C	--	--	--	--	--	--
Viscosity index improver, wt% ** e^1	4.0	5.8	6.5	5.5	7.7	--
e^2	--	--	--	--	--	6.5
e^3	--	--	--	--	--	--
Other additives	Added	Added	Added	Added	Added	Added
Kinematic viscosity (mm²/s)　　at 40°C	11.2	11.4	11.3	11.6	12.0	10.7
at 100°C	3.1	3.3	3.4	3.3	3.6	3.4
Viscosity index	149	176	187	171	207	222
BF viscosity (mPa·s) at -40°C	1650	1320	1260	1460	1300	560
NOACK evaporated quantity (wt%)	4.3	7.7	8.6	6.6	10.4	2.2
Shear stability, determined by the sound wave method Viscosity reduction rate (%) at 100°C	4.0	5.7	5.9	5.4	7.6	5.1

* Based on the whole composition

** Each of e^1, e^2 and e^3 is a polymethacrylate-based viscosity index improver, having a weight-average molecular weight of 75,000, 100,000 and 45,000, respectively.

TABLE 1 (continued)

	Example 7	Example 8	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Deeply dewaxed mineral oil (a), wt% * Kinematic viscosity: 2.4 mm²/s at 100°C	--	50	--	100	--	70
Low-viscosity mineral oil (b), wt% *						
(b¹) Kinematic viscosity: 1.8 mm²/s at 40°C	--	--	--	--	--	30
(b²) Kinematic viscosity: 3.1 mm²/s at 40°C	--	--	--	--	--	--
Normal solvent dewaxed mineral oil (a), wt% * Kinematic viscosity: 2.7 mm²/s at 100°C	--	--	100	--	--	--
Poly-α-olefin (c), wt% * (c¹) Kinematic viscosity: 1.7 mm²/s at 100°C	80	50	--	--	80	--
Ester compound (d), wt% *						
(d¹) Kinematic viscosity: 2.4 mm²/s at 100°C	20	--	--	--	20	--
(d²) Kinematic viscosity: 4.3 mm²/s at 100°C	--	--	--	--	--	--
Viscosity index improver, wt% ** e¹	--	--	--	21.0	--	15.0
e²	7.5	10.0	--	--	26.0	--
e³	--	--	2.0	--	--	--
Other additives	Added	Added	Added	Added	Added	Added
Kinematic viscosity (mm²/s) at 40°C	11.5	12.3	11.8	28.0	62.0	14.4
at 100°C	3.5	3.9	3.1	8.0	20.2	4.9
Viscosity index	214	299	126	283	346	320
BF viscosity (mPa•s) at -40°C	660	800	4700	2300	2100	1100
NOACK evaporated quantity (wt%)	1.9	3.1	2.8	5.5	2.5	29.6
Shear stability, determined by the sound wave method Viscosity reduction rate (%) at 100°C	4.7	9.8	0	20.3	15.2	14.8

EXAMPLES 2 TO 8

[0056] A hydraulic oil composition for shock absorbers was prepared in each of Examples 2 to 8, with the lubricant base oil components and a viscosity index improver and other additives in a composition given in Table 1, where ratio of the base oil components is based on the whole base oil whereas that of the additives is based on the whole composition. Each composition was measured for its viscosity characteristics, volatility and shear stability, and evaluated by these characteristics. The results are given in Table 1. As shown composition had high qualities as the one for shock absorbers.

COMPARATIVE EXAMPLES 1 TO 4

[0057] A hydraulic oil composition for shock absorbers was prepared in each of Examples 2 to 8, with one or more lubricant base oil components and a viscosity index improver and other additives in a composition given in Table 1.

[0058] Comparative Example 1 used a normal solvent-dewaxed mineral oil (pour point: -15°C and kinematic viscosity: 2.7 mm²/s at 100°C) as the base oil in place of the deeply dewaxed mineral oil, which was incorporated with a polymethacrylate-based viscosity index improver (weight-average molecular weight: 45,000) at 1.5 wt% based on the whole composition. The composition had insufficient viscosity characteristics at low temperature, with a Brookfield viscosity of 4700 mPa·s at -40°C.

[0059] Comparative Example 2 used the deeply dewaxed mineral oil having a kinematic viscosity of 2.4 mm²/s at 100°C as the base oil, which was incorporated with a polymethacrylate-based viscosity index improver (weight-average molecular weight: 75,000) at 21.0 wt% based on the whole composition. The composition was insufficient both in viscosity characteristics at low temperature, with a Brookfield viscosity of above 2000 mPa·s at -40°C and in shear stability.

[0060] Comparative Example 3 used the synthetic oil of poly-α-olefin and ester compounds as the base oil, which was incorporated with a polymethacrylate-based viscosity index improver (weight-average molecular weight: 100,000) at 26.0 wt% based on the whole composition, to have a kinematic viscosity of 20.2 mm²/s at 100°C. The composition was insufficient both in viscosity characteristics at low temperature, with a Brookfield viscosity of above 2000 mPa·s at -40°C and shear stability.

[0061] Comparative Example 4 used a mixed base oil of 70 wt% of the deeply dewaxed mineral oil having a kinematic viscosity of 2.4 mm²/s at 100°C and 30 wt% of the low-viscosity mineral oil having a kinematic viscosity of 1.8 mm²/s at 40°C (both percentages were based on the whole base oil), which was incorporated with a polymethacrylate-based viscosity index improver (weight-average molecular weight: 75,000) at 15.0 wt% based on the whole composition. The composition, although showing good viscosity characteristics at low temperature, had NOACK evaporated quantity apparently deteriorated and shear stability also deteriorated.

[0062] The hydraulic oil composition of the present invention for shock absorbers shows excellent low-temperature viscosity characteristics, volatility, shear stability, and in particular damping force stability from high to low temperature, which are required for a hydraulic oil composition for shock absorber, by using a deeply dewaxed mineral oil and/or synthetic oil having specific properties as the base oil, which is incorporated with specific quantity of a viscosity index improver and/or pour point depressant, to have a kinematic viscosity at 100°C, viscosity index and Brookfield viscosity at -40°C in specific ranges.

Claims

1. A hydraulic oil composition for shock absorbers, comprising a base oil selected from the group consisting of a mineral oil (A), synthetic oil (B) and mixtures thereof incorporated with 20 wt% or less, based on the whole composition, of one or more of a viscosity index improver, pour point depressant, and having the following viscosity characteristics; kinematic viscosity of 1 to 20 mm²/s at 100°C, viscosity index of 140 or more and Brookfield viscosity of 2000 mPa·s or less at -40°C, wherein said mineral oil (A) is a deeply dewaxed mineral oil (a) having a kinematic viscosity of 2 to 3 mm²/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less, or a mixed mineral oil of the deeply dewaxed mineral oil (a) and a low-viscosity mineral oil (b) having a kinematic viscosity of 1.0 to 6.0 mm²/s at 40°C wherein the content of the low-viscosity mineral oil (b) is below 20 wt%, based on the whole mixed mineral oil, and said synthetic oil (B) is selected from the group consisting of a poly-α-olefin (c) having a kinematic viscosity of 1.5 to 45 mm²/s at 100°C, an ester compound (d) having a kinematic viscosity of 1.5 to 20 mm²/s at 100°C and pour point of -30°C or less and mixtures thereof.

2. The hydraulic oil composition of claim 1 wherein the low viscosity mineral oil (b) has a kinematic viscosity of 1.0 to 2.5 mm²/s at 40°C.

3. The hydraulic oil composition of claim 1 wherein the low-viscosity mineral oil (b) has a kinematic viscosity of 2.5 to 6.0 mm^2/s at 40°C.

4. The hydraulic oil composition of any preceding claim wherein the deeply dewaxed mineral oil of (a) has a kinematic viscosity of 2 to 3 mm^2/s at 100°C, pour point of -35°C or less and cloud point of -30°C or less.

5. The hydraulic oil composition of claim 1 wherein the base oil is synthetic oil (B) comprising 70 to 90 wt% poly-α-olefin (c) and 10 to 30 wt% of ester (d).

6. A hydraulic oil composition for shock absorbers, comprising a base oil composed of a deeply dewaxed mineral oil (a) having a kinematic viscosity of 2 to 3 mm^2/s at 100°C, pour point of -30°C or less and cloud point of -27.5°C or less and a synthetic oil selected from the group consisting of poly-α-olefin (c) having a kinematic viscosity of 1.5 to 45 mm^2/s at 100°C, ester compound (d) having a kinematic viscosity of 1.5 to 20 mm^2/s at 100°C, and a pour point of -30°C or less, and mixtures thereof, incorporated with 20 wt% or less, based on the whole composition of one or more of a viscosity index improver, a pour point depressant, said hydraulic oil composition having a kinematic viscosity of 1 to 20 mm^2/s at 100°C, a viscosity index of 140 or more and Brookfield viscosity of 2000 mPa•S or less at -40°C.

7. The hydraulic oil composition of any preceding claim wherein the viscosity index improver is selected from the group consisting of polymethacrylate, olefin copolymer, star shaped polymer and mixtures thereof and the pour point depressant is selected from the group consisting of acrylate based polymer, polymethacrylate based polymer and mixtures thereof.